



ITM integration, parallelization of ESEL, HDF 5

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The Integrated Tokamak Modeling Task Force (ITM-TF)

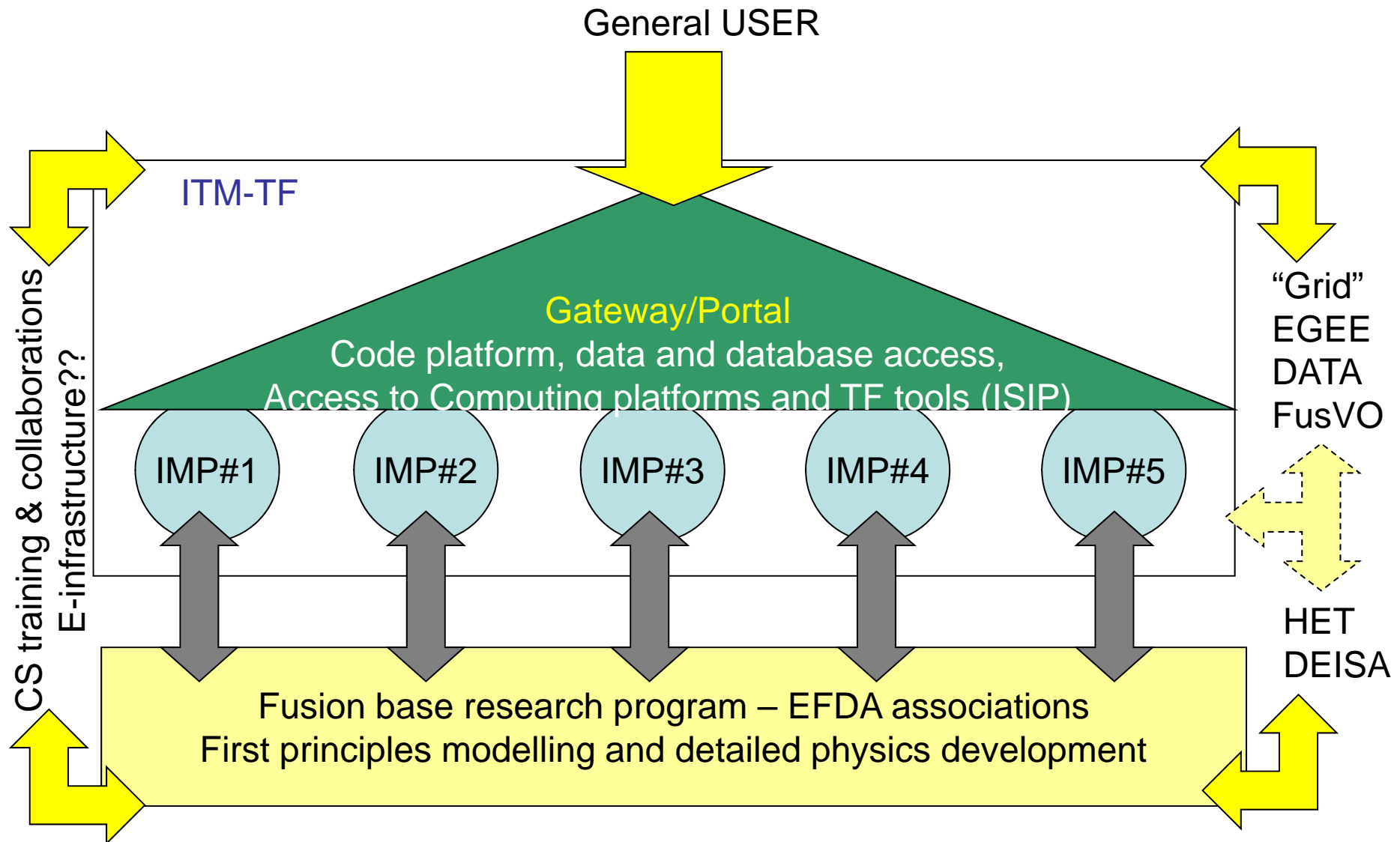
*The Integrated Tokamak Modeling Task Force (ITM-TF) has the **long-term aim to provide the EU** with suite of **codes necessary for preparing and analyzing future ITER discharges**, with the highest degree of flexibility, confidence and reliability.*

Taskforce Leader: Paar Strand

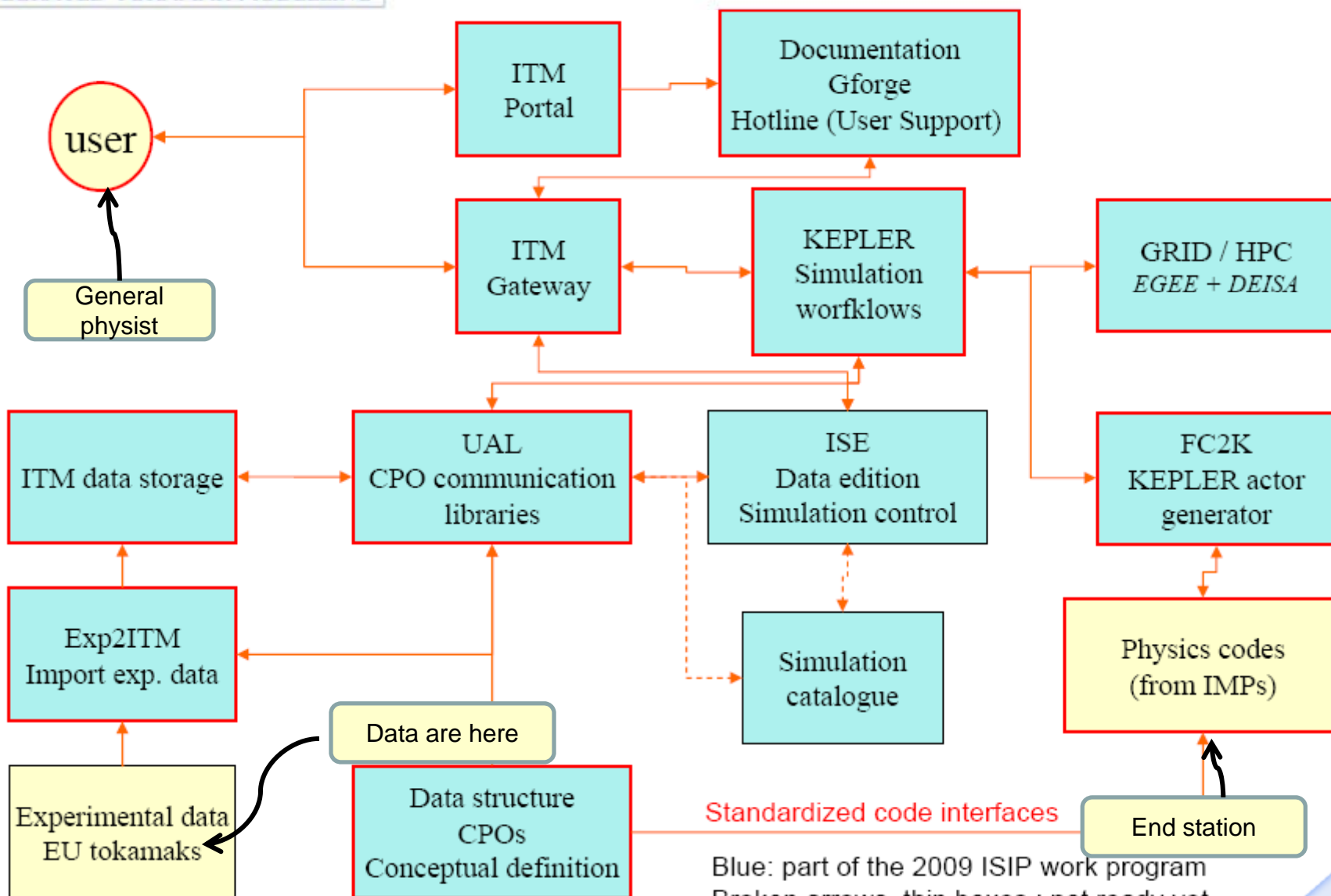
Five Integrated Modeling Projects (IMP)

- IMP#1 Equilibrium and MHD
- IMP#2 Non linear MHD, sawtooth and ELMs
- IMP#3 Energy and particle transport
- **IMP#4 First principle transport and turbulence (Bruce Scott)**
- IMP#5 Fast particles and heating
- ISIP Infrastructure Support Project (UAL, Kepler, ESE,..) (F. Imbeaux)

Schematics



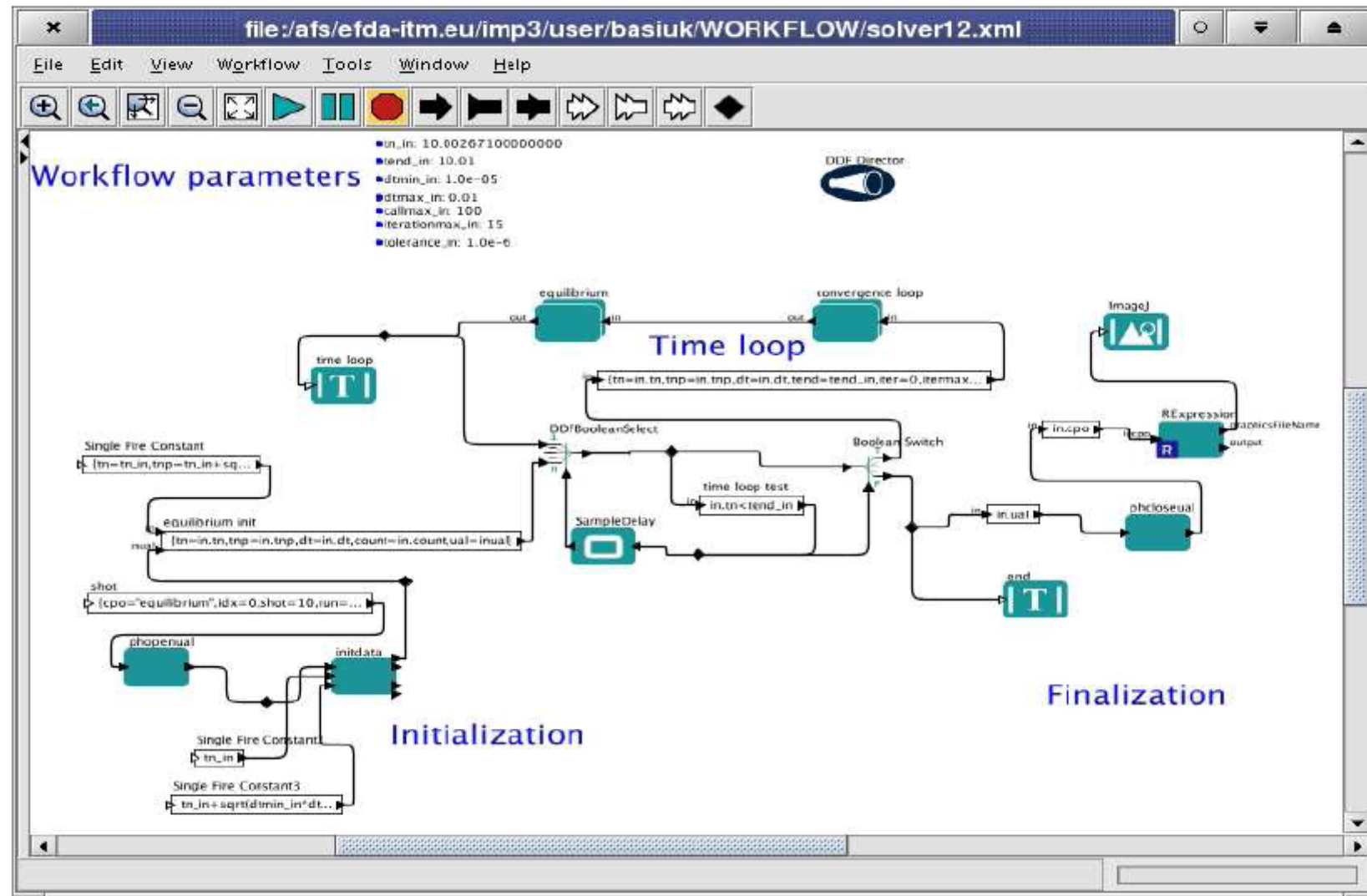
ISIP overview



Blue: part of the 2009 ISIP work program
Broken arrows, thin boxes : not ready yet
The rest is ready, at least in a first prototype version

Overview

- Data Structure : Physics data organised in Consistent Physical Objects (CPO) : standard of communication between physics modules. Thought in view of modular and flexible workflow design
 - coded as XML schemas, a series of XSL transforms turn them into HTML documentation, language specific libraries, machine description file, ...
- UAL : Communication library between physics modules : allows to exchange CPOs
 - Available in Fortran, C++, Java, Matlab, Python
 - Generated dynamically from the data structure
 - Uses MDS+ as backend (HDF5 option exists but through MDS+ software)
 - Read/Write from/to disk (default) or memory
- KEPLER : design and runs workflows, with wrapped physics modules as elementary "acting units"
 - Integrated platform developed in San Diego, used by some of the US FSP
 - Drag and drop physical modules « actors » to create workflows



CPO transfer in KEPLER

- Physics modules are subroutines expecting CPOs as input and output
 - No need to use the UAL in a physics module, except for testing purposes
 - Physics modules must be wrapped in a layer that deals with the UAL calls
 - The wrapping is done automatically by the FC2K interface
 - Wrapped physics modules are called « actors » and are usable by KEPLER
- CPO transfer in KEPLER is done by linking actors with an « arrow »
 - This arrow may correspond to a CPO or a workflow parameter (e.g. time)
 - When the arrow represents a time-dependent CPO, all time slices are potentially transferred (default mode)
 - **Exception : for CPOs declared in « single time slice » mode at the actor generation (FC2K), the wrapper will GET the latest time slice of the CPO before the current time and PUT the output at the current time. The current time is given to the actor as an explicit KEPLER variable.**
 - CPOs are not native KEPLER variables. The CPO transfer is done in fact by the « wrapper », not by KEPLER

Outside the Physics module

Framework (Kepler)

Calls the wrapper, specifying the present time of the simulation

Wrapper

Calls UAL to GET the CPOin and CPOout at the requested time slices

Physics code

Receives CPOin, CPOout,

Physics calculations

Updates CPOout

Updates data management nodes

Calls UAL to PUT the CPOout

UAL

UAL

Work run number

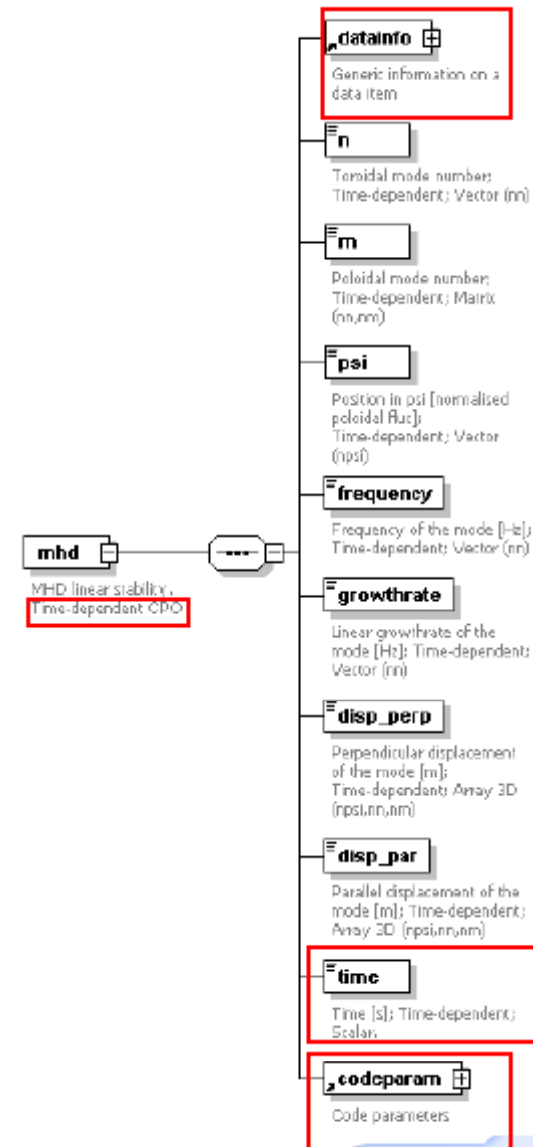
Temporary database entry

Instance of the whole datastructure

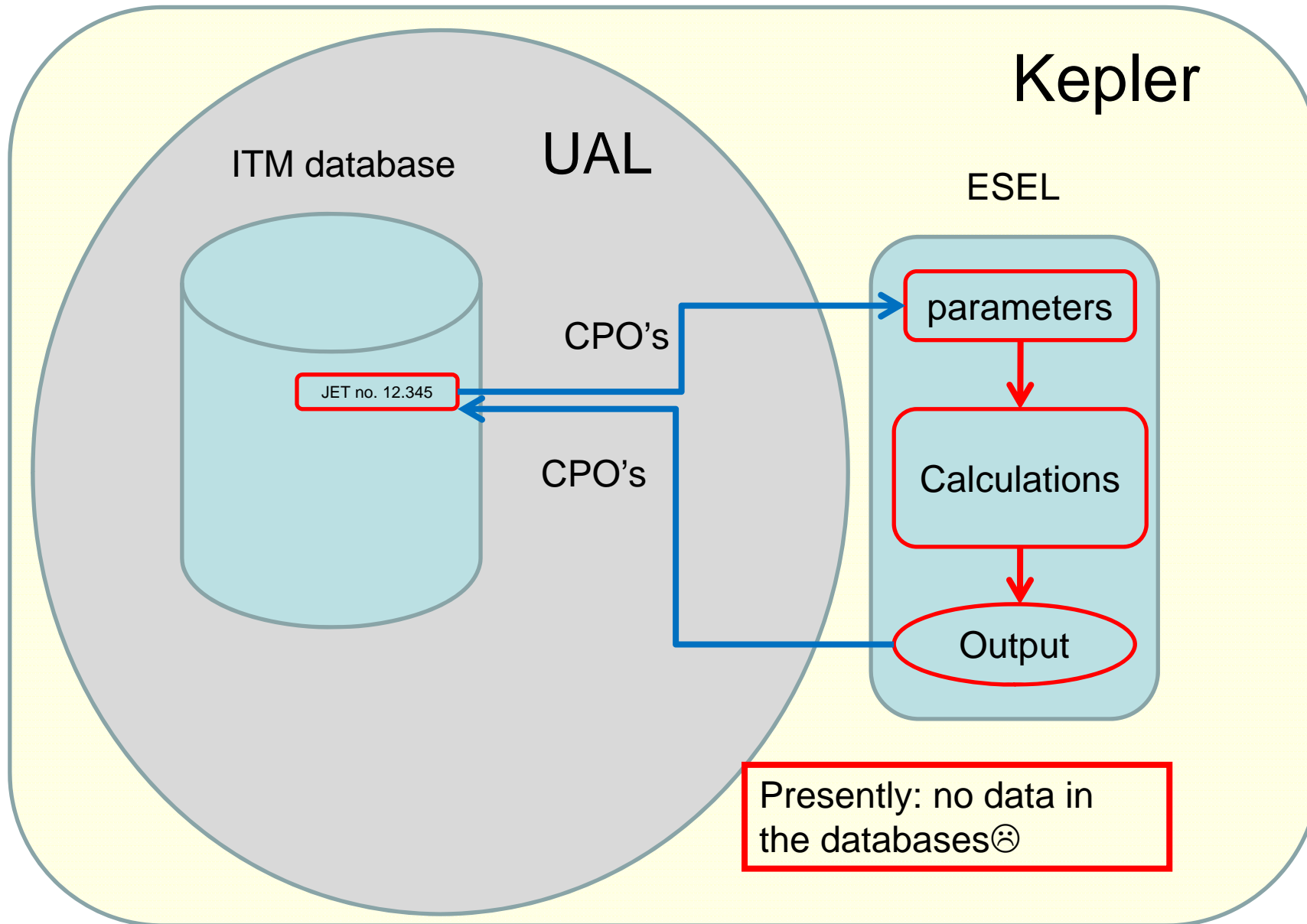
Contains the state of all CPOs at all time slices

CPO structure

- CPOs have a structure with many signals below
 - Substructures are frequent
 - Fine structure depends on the physics
 - All physics signals related to a CPO are there
- Each CPO has its own time array (if time-dependent)
- Each CPO has a bookkeeping sub-structure (datainfo)
- Code-specific parameters are in codeparam



ITM: my interpretation



Example of standalone wrapper program

```
program test
```

```
use eulTM_schemas  
use eulTM_routines
```

```
implicit none
```

```
integer,parameter :: DP=kind(1.0D0)
```

```
interface  
  subroutine physics(coreprofin,mhdout)  
    use euitm_schemas  
    !use euitm_routines  
    type (type_coreprof),pointer :: coreprofin(:)  
    type (type_mhd),pointer :: mhdout(:)  
  end subroutine  
end interface
```

```
type (type_coreprof),pointer :: coreprofin(:)  
type (type_mhd),pointer :: mhdout(:)
```

```
integer :: idxin, idxout, shot, runin, runout, refshot, reffrun  
integer :: numDims,dim1,dim2,dim3
```

```
character(len=5)::treename  
shot = 4  
runin = 1  
runout = 2  
refshot = 0 ! Dummy, not used  
reffrun = 0 ! Dummy, not used  
treename = 'euitm' ! Mandatory, do not change
```

```
write(*,*) 'Open shot in MDS !'  
call euitm_open(treename,shot,runin,idxin)
```

```
write(*,*) 'Reading the input CPO :'  
call euitm_get(idxin,"coreprof",coreprofin)
```

```
write(*,*) 'Calling the physics subroutine :'  
call ESEL(coreprofin,mhdout)
```

```
write(*,*) 'Creating output run :'  
call euitm_create(treename,shot,runout,refshot,refrun,idxout)
```

```
write(*,*) 'Put result'  
call euitm_put(idxout,"mhd",mhdout)
```

```
write(*,*) 'Closing Database :'  
call euitm_close(idxin,treename,shot,runin)  
call euitm_close(idxout,treename,shot,runout)
```

```
write(*,*) 'Deallocate CPOs :'  
call euitm_deallocate(coreprofin)  
call euitm_deallocate(mhdout)  
end
```

Note: The other IMP's will write data to the databases through the CPO's but IMP4 will (mostly) store HDF in HDF5 data files

HDF5

(Hierarchical Data Format)

The official data format for IMP4

One simulation, one file:

A single file containing all fields at all time slices, including probes (compressed) (~0.5 GB)

FUTILS: FORTRAN wrapper developed and maintained by CRPP Lausanne:

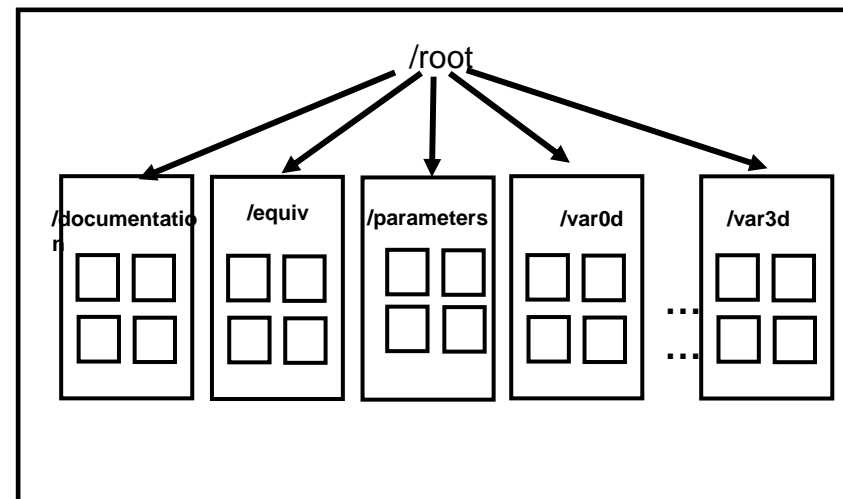
<http://pleiades1.epfl.ch/~tmt/pub>

Does NOT support parallel read/write ☹️

Matlab and graphics programs interface for reading/writing HDF5 files

HDF5 is a data model, library, and file format for storing and managing data. It supports an unlimited variety of data types, and is designed for flexible and efficient I/O and for high volume and complex data. HDF5 is portable and is extensible, allowing applications to evolve in their use of HDF5.

From: <http://www.hdfgroup.org/HDF5/>



Parallelization of ESEL

- ESEL is presently being parallelized at *Åbo Akademi University, Department of Information Technologies, Finland.*
- Domain decomposition
- Information about boundary values need to be communicated between neighboring domains/CPU's every time step
- A parallel Poisson/Helmholtz solver are needed
- Presently 16 – 32 CPU are the upper limits due to parallel write bottlenecks. Hopefully 100 CPUs should be achieved.

